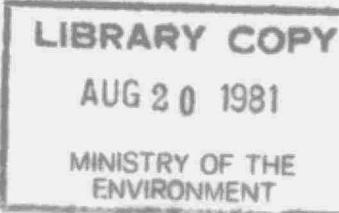


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AIR QUALITY STUDIES
in the vicinity of
THUNDERBRICK LIMITED, ROSSLYN

1980

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TECHNICAL SUPPORT SECTION
NORTHWESTERN REGION
ONTARIO MINISTRY OF THE ENVIRONMENT

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SUMMARY

In 1980, fluoride emissions from Thunderbrick Limited continued to cause acute injury to sensitive vegetation in a nearby residential area in Rosslyn Village. Resistant vegetation was undamaged. All vegetation sampled on and near company property contained abnormally high fluoride concentrations, and fluoride levels declined sharply as distance from the brick plant increased.

Moss exposure experiments and lime candle measurements confirmed the presence of elevated levels of airborne fluoride within approximately 200 metres of the company's property line. In this area, provincial air quality objectives were often not met. Fluoride concentrations, however, were still well below levels required to cause health effects.

Process changes have been recently implemented at the brick plant to decrease significantly the use of raw materials containing high fluoride. An abatement programme to ensure compliance with provincial regulations is being negotiated with the company.

INTRODUCTION

Thunderbrick Limited operates a brick and tile manufacturing plant in Rosslyn Village on the western outskirts of the City of Thunder Bay. Air quality investigations conducted since 1977 by the Ministry of the Environment showed that sensitive garden vegetation in a nearby residential area had been injured by airborne fluoride emissions from the brick plant. Elevated fluoride concentrations were also recorded in vegetation foliage up to 300 m (metres) outside the company's property line (1, 2, 3) and average monthly levels of airborne fluoride, as measured by lime candles located within 200 m of company property line, frequently exceeded Ontario's air quality objectives. There was no evidence that airborne fluoride in the area constituted a threat to public health.

Surveillance investigations in the vicinity of Thunderbrick continued in 1980 with measurements of airborne fluoride throughout the year, and vegetation studies during the summer months.

VEGETATION EFFECTS

VEGETATION INJURY

Indigenous Vegetation

On three occasions, naturally-occurring vegetation in the vicinity of the brick plant was examined. As in previous years, there was no evidence of fluoride injury symptoms on indigenous plants. Symptoms resembling fluoride injury were observed on needles of red pine (Pinus resinosa) trees on company property near the main entrance to the brick plant on the south side of Rosslyn Road. Foliage on three planted red pine on a residential property 140 m N of the brick plant also showed evidence of similar injury. Further observations and sampling from these trees during the 1981 growing season should establish whether fluoride is the cause of this damage. Moderate to severe insect defoliator damage, caused by forest tent caterpillars was observed on black ash and trembling aspen foliage in the survey area.

Garden Plants

A number of private residential gardens in an area extending approximately 600 m from the brick plant were examined in late August. Typical symptoms of acute fluoride injury were observed on foliage of gladiolus plants in gardens along portions of Rosslyn Road within 200 m of the brick plant. Based on past experience, fluoride damage to gladioli might have been expected up to 400 m, but no gladioli had been planted in 1980 by residents in the area between 200 and 400 m from the brick plant.

On June 30, 1980, experimental plots of potted gladioli (variety "Snow Princess") were established in a residential area 130 m north-northwest of the brick plant and at a control site approximately 20 km (kilometres) from the study area. Only one main shoot was permitted to develop for each of the 12 plants at each site, with secondary shoots being cut back during the period of the experiment. Records were kept of plant height and the development of pollutant injury symptoms. Pots were watered and weeded as required.

A summary of the development of fluoride injury to the gladioli is presented in Table 1. Fluoride damage first appeared on July 8 as terminal necrosis (dead tips) of leaf tissue, and increased in extent and severity until late August. The slight decrease in average length of injured tissue at the end of August was attributed to breakage and loss of the brittle, necrotic leaf tips. The injury rating for experimental gladioli was similar in 1980 to that reported for previous years.

FLUORIDE LEVELS IN VEGETATION

Tree Foliage

Single samples of trembling aspen (Populus tremuloides) foliage were collected on August 28 from 22 locations around the brick plant (Figure 1). Sampling and analytical procedures were the same as those described in the 1977 report (1).

Fluoride concentrations in the vicinity of the brick plant, plotted in Figure 2, were well above the 12 µgF/g recorded at the control stations. Highest fluoride levels occurred on and near company property and decreased rapidly as distance from the brick plant increased. The fluoride levels in trembling aspen foliage were similar to those found in previous years.

Chemical analysis data for red pine foliage is presented in Table 2. Fluoride concentrations at the two sites near the emission source were 2.5 to 5 times higher than those at the controls. Further sampling is planned during 1981.

Forage

Four sets of forage (grass) samples were collected from five locations in a farm pasture west of the brick plant (Figure 1) and from two control sites. All fluoride levels, reported in Table 3, were within the Ontario objective of 35 µgF/g, dry weight, and well below concentrations known to be toxic to livestock.

Experimental Gladioli

Four plants from each gladiolus plot were harvested on August 1, and the remainder on August 29. Fluoride analytical results are presented in Table 4. The fluoride content in whole leaves of gladioli near the brick plant was approximately four times greater than that in plants at the control site. Leaf tissue killed by excess fluoride contained nearly six times as much fluoride as uninjured tissue and approximately 19 times as much as leaves from control plants.

Acute, severe fluoride injury symptoms were also found on gladioli planted by a resident in his garden near our experimental plot. Whole leaves from his plants contained 50 µg/g fluoride, higher than the fluoride content of our test plants.

AIRBORNE FLUORIDE LEVELS

EXPERIMENTALLY EXPOSED MOSS

Mosses are effective in absorbing and retaining some types of airborne contaminants. Bags of Sphagnum moss were set out at monthly intervals from June to August at 22 sites (Figure 1) near the brick plant and at two distant control locations. Each sample comprised about 4 g (grams) of oven-dried moss contained in a 10 by 20 cm envelope of polypropylene screening attached to a plastic supporting bracket about 2.5 m above ground level.

Moss analysis results, in Table 5, showed that significantly elevated concentrations of airborne fluorides were present in the study area during the survey periods. The monthly variation in fluoride levels from June to August probably reflected changes in production rates and prevailing wind directions. The rapid decrease of fluoride in moss as distance from the brick plant increased showed that the brick plant was the source of fluoride emissions. Fluoride levels in moss were generally similar in 1979 and 1980.

FLUORIDATION RATE

Lime candles provide an indication of average fluoride levels in air during specified exposure periods. The principle of the method is described in a previous report (2). Monthly readings for 1980 are reported in Table 6 for six monitoring locations (Figure 3) around Thunderbrick. The Ontario air quality objectives for fluoridation rates were frequently exceeded, especially during the growing season at the three sites to the north and northeast of the brick plant. Approximately two-thirds of the readings from all sites combined exceeded the objective of 40 µgF/100 cm²/30 days for the growing season (May 1 to September 30).

From January to March, clay consumption at the brick plant was at an unusually low level. In March, Thunderbrick suspended production of clay bricks and began manufacturing tiles from shale. Consumption of shale was at a much higher rate than

that of clay during the first three months of the year. In addition, the fluoride content was found to be substantially higher in shale than clay. The increased production rates and higher fluoride levels in the raw material resulted in a significant increase in fluoride emissions and, consequently, higher readings in the lime candles in April and following months. Reduced fluoridation rates near the end of the year were attributed, at least in part, to normal seasonal changes in prevailing wind direction.

The relationship between lime candle data and fluoride concentrations in experimentally exposed moss was also investigated. Results are presented in Table 7. From June to October (except September) there was a good correlation ($r = 0.81$ to 0.97) between monthly lime candle readings and fluoride levels in moss. The breakdown of the relationship in November and December may have been caused by cold temperatures which inhibited the absorption of fluoride in moss or the reaction between fluoride and the lime candles. Further tests are planned for 1981.

SEVERITY INDEX RATING

An index has been developed by the Ministry to compare vegetation effects in the vicinity of fluoride-emitting industries (4). On a scale of 0 to 100, the severity index rating for Thunderbrick in 1980 was 54. Comparable values for 1979 and 1978 were 46 and 51, respectively. Therefore, the overall effects of fluoride emissions from the brick plant showed little change during the past three years.

ABATEMENT PROGRAM

The company has recently implemented a process change to reduce the shale content of its product from 100 percent to approximately 60 percent. Materials low in fluoride comprise the other 40 percent. This action has resulted in a significant decrease in fluoride emissions. There is some evidence that modifications to the lime kiln, completed in late 1980, also assisted in reducing fluoride discharge.

Because production levels at Thunderbrick may fluctuate considerably, depending on market conditions, further controls will be required. An abatement programme designed to achieve compliance with Ontario regulations is currently being negotiated with the company.

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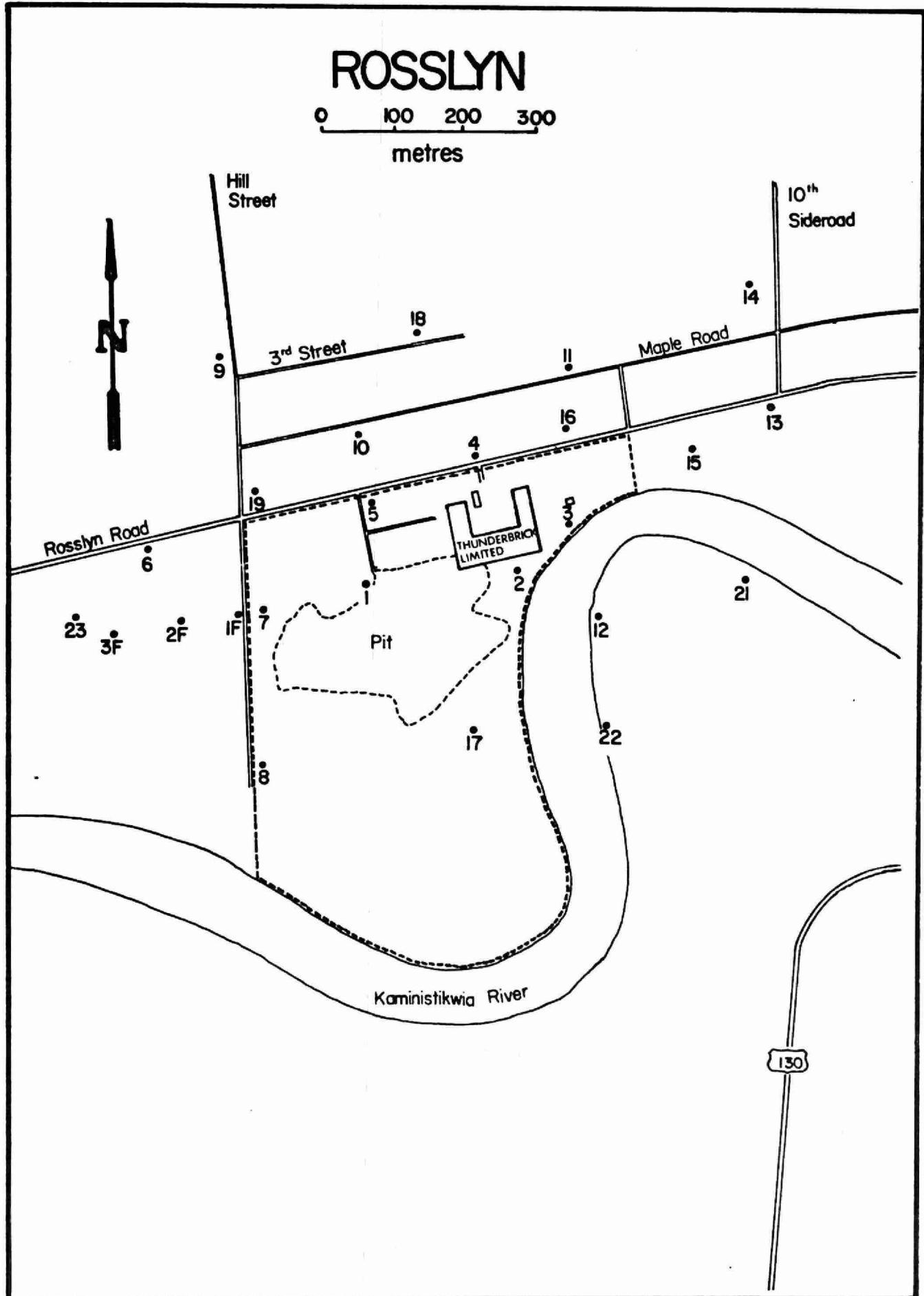
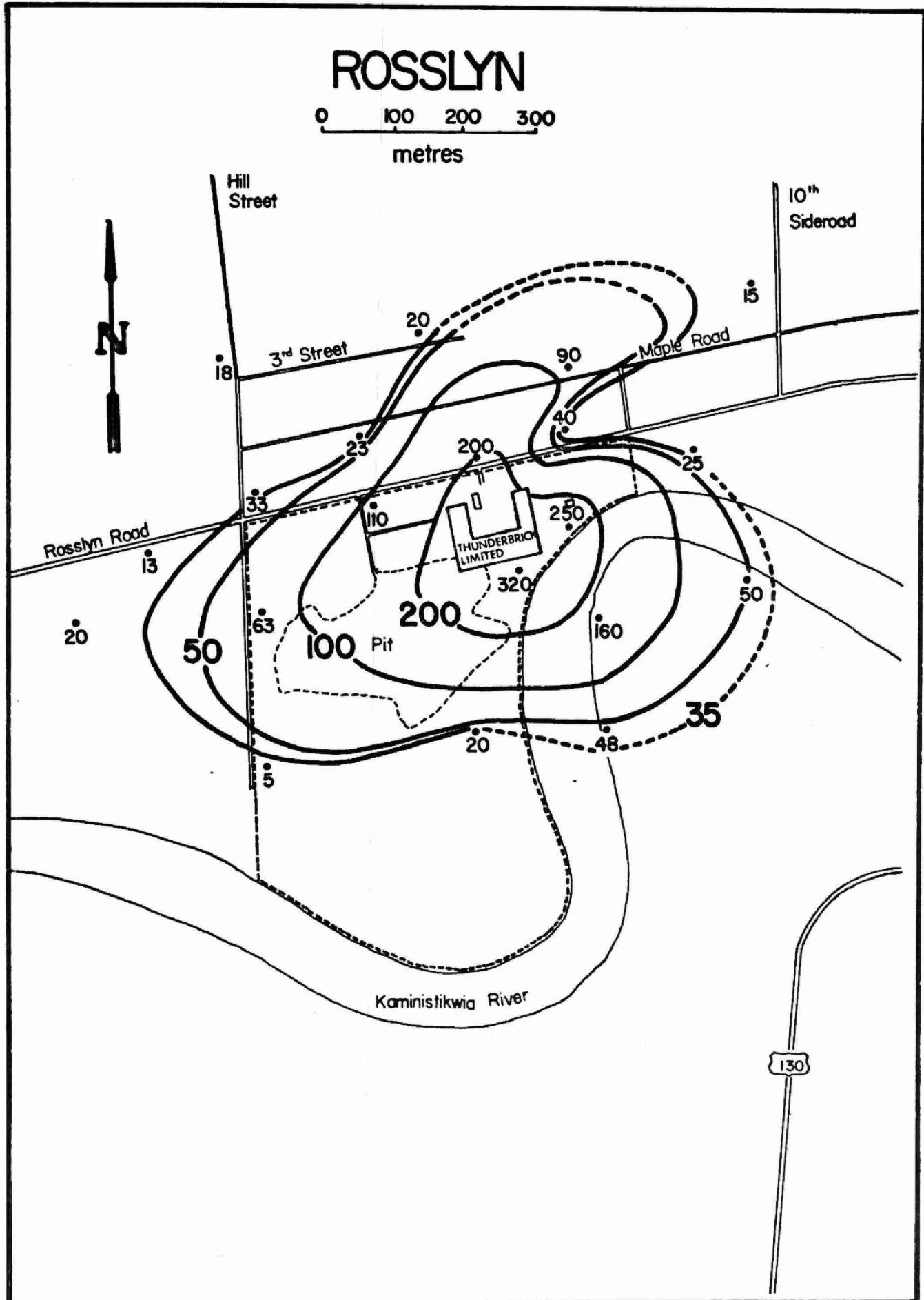


Figure I. Trembling aspen, forage sampling and moss bag exposure sites, 1980.
(IF designates forage)



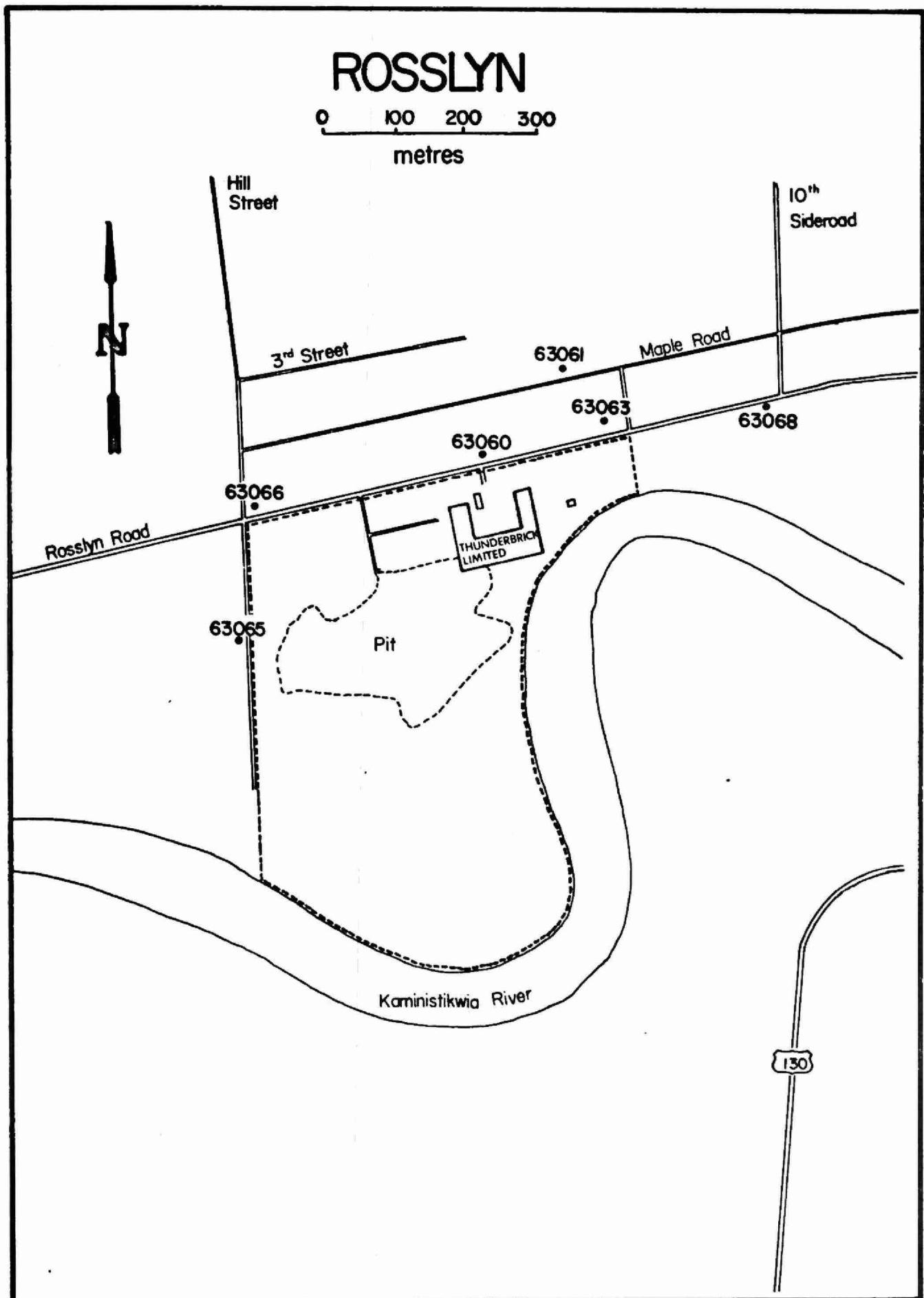


Figure 3. Air quality monitoring sites, 1980.

TABLE 1. Average length (cm) of necrotic tissue caused by fluoride injury on main shoot of experimental gladioli grown near Thunderbrick in 1980.

Date	Distance (metres) and direction of test sites from source	
	130 m NNW	20000 m ENE
Jul 8	trace (2) ^a	nil
15	1.3 (4)	nil
21	3.4 (8)	nil
31	4.0 (11)	nil
Aug 11	12.6 (7) ^b	nil
29	10.2 (8)	nil

^aNumber of plants affected is shown in parentheses.

^bFour gladioli plants removed for chemical analyses.

TABLE 2. Levels of fluoride ($\mu\text{g/g}$, dry weight) in red pine foliage, Rosslyn Village, 1980.

Distance (metres) & direction from source	Red pine	
	1980 Foliage	1979 Foliage
125 m NNW	105	108
140 m N	48	105
3000 m NE	20	13

TABLE 3. Fluoride levels ($\mu\text{g/g}$, dry weight) in forage, 1980.

Site	May	Jun	Jul	Aug
1 F	13	10	10	20
2 F	17	8	13	13
3 F	8	8	10	8
Controls	5	8	18	8

TABLE 4. Fluoride concentrations ($\mu\text{g F}$ per g of dried leaf tissue) in gladiolus foliage, 1980.

Date	Sample	Distance (metres) and direction from brick plant	
		135 m NNW	20000 m ENE
Aug 1	Uninjured tissue	33	
	Injured tissue	138	
	Whole leaf	30	7
Aug 29	Uninjured tissue	25	
	Injured tissue	200	
	Whole leaf	38	11

TABLE 5. Monthly fluoride levels ($\mu\text{g/g}$, dry weight) in experimentally exposed moss, Rosslyn Village, 1980.

Site	Jun	Jul	Aug	Average
1	75	50	95	73
2	160	500	150	270
3	-	280	300	290
4	87	180	120	130
5	62	70	120	84
6	55	58	60	58
7	38	35	33	35
8	25	23	20	23
9	40	23	40	34
10	25	23	28	25
11	95	93	100	96
12	97	75	120	97
13	65	58	95	73
14	32	23	33	29
15	52	75	43	57
16	75	120	60	85
17	50	33	30	38
18	40	50	40	43
19	37	30	-	34
21	32	28	20	27
22	50	30	33	38
23	75	33	70	59
Exposed controls	21	14	19	18
Unexposed controls	15	14	14	14

TABLE 6. Fluoridation rates ($\mu\text{g F}/100 \text{ cm}^2/30 \text{ days}$), Rosslyn Village, 1980.

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
63060	31	4	22	52 ^a	<u>87</u>	<u>167</u>	<u>401</u>	<u>303</u>	- ^b	<u>148</u>	2	<u>127</u>	122
63061	14	4	17	41	<u>78</u>	<u>183</u>	<u>204</u>	<u>172</u>	-	48	24	18	73
63063	8	6	6	-	<u>46</u>	<u>105</u>	<u>193</u>	<u>78</u>	-	39	63	21	56
63065	11	8	14	43	<u>73</u>	<u>45</u>	28	20	-	19	7	10	25
63066	6	5	8	27	24	28	23	31	-	17	4	9	17
63068	9	6	7	11	36	<u>64</u>	38	<u>44</u>	-	9	33	18	25

^avalues exceeding air quality objectives of 40 $\mu\text{g F}$ (May-September) and 80 $\mu\text{g F}$ (October-April) are underlined.

^bno fluoridation rates available for September.

TABLE 7. Fluoride levels ($\mu\text{g/g}$) in moss and fluoridation rates ($\mu\text{g F}/100 \text{ cm}^2/30 \text{ days}$) from lime candles, Thunderbrick Limited, 1980.

Site	Jun		Jul		Aug		Sep		Oct		Nov		Dec	
	C ^a	M ^b	C	M	C	M	C	M	C	M	C	M	C	M
63060	167	87	401	175	303	125	-	73	148	130	2	78	127	38
63061	183	95	204	93	172	105	-	50	48	42	24	28	18	15
63063	105	75	193	120	78	60	-	48	39	78	63	65	21	38
63065	45	38	28	35	20	33	-	15	19	39	7	35	10	12
63066	28	37	23	30	31	-	-	10	17	40	4	22	9	12
63068	64	65	38	58	44	95	-	15	9	22	33	28	18	30
Coefficient of determination (r^2)	0.91		0.94		0.66		-		0.87		0.03		0.36	

^afluoridation rates ($\mu\text{g F}/100 \text{ cm}^2/30 \text{ days}$) from lime candles.

^bfluoride levels ($\mu\text{g/g}$, dry weight) in moss.

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